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COSMIC CLUTTER

Man-made space debris threatens everything from national security to Super Bowl Sunday

By Matt Alderton

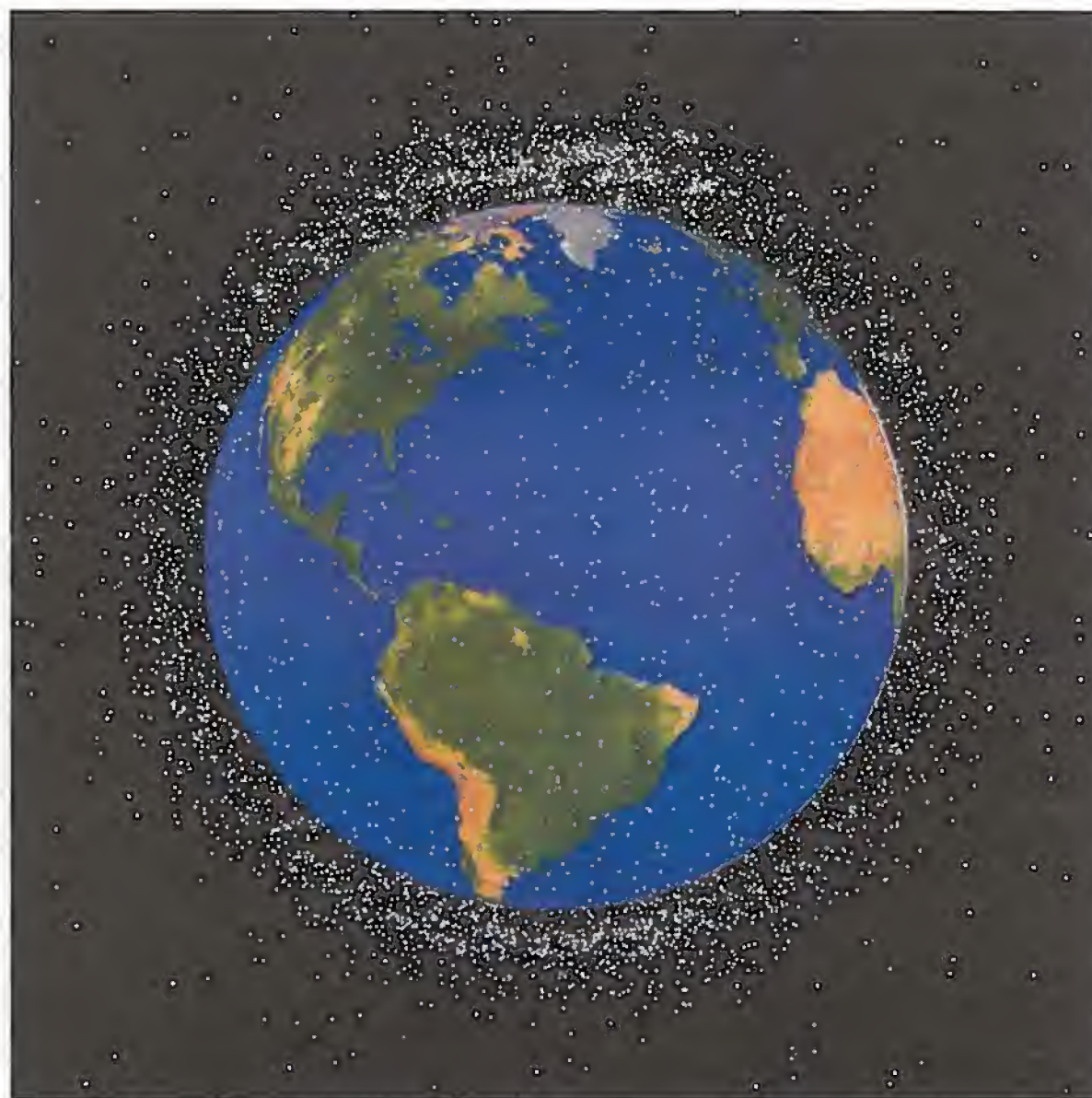
THE CITARUM RIVER in Indonesia is the world's dirtiest river. About 186 miles long, it supplies water to 30 million people. And yet, it's festooned with garbage. A hodgepodge of plastic bottles, cigarette butts and food wrappers, it's an environmental assault too obvious to ignore, and the Indonesian government is spending several billion dollars to clean it up.

About 500 miles above the river, in an altitude of space known as low-Earth orbit, a celestial Citarum is taking shape. Consisting of a half century's worth of man-made space debris — everything from derelict spacecraft and discarded launch rockets to explosive bolts, lens caps and flecks of chipped paint — it's an environmental issue of cosmic proportions.

"The space debris problem is a pollution problem," said Dave Baiocchi, a senior engineer at Rand Corp. and co-author of *Confronting Space Debris*. "The problem is hard to solve, however, because it's something the public can't see."

The public may be blind to space debris, but the international space community sees it clearly. Led by NASA and the U.S. Air Force, among others, this community works around the clock to keep Earth's orbit safe for space travel by locating, tracking and mitigating "space junk."

The U.S. Air Force tracks about 23,000 space-borne objects. Of those, about 1,200 are active satellites. The rest are orbital debris resulting from accidental explosions and collisions, and from the deliberate separation of spacecraft from their launch rockets. Most of this debris, including tens of millions of smaller particles that are too small



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to track, resides within 1,250 miles of Earth's surface, where it orbits the planet at speeds of up to 5 miles per second — fast enough to fly from Los Angeles to New York in less than 10 minutes.

Debris in the lowest altitudes typically falls to Earth within a few years. But the stuff that circles in the same orbits as satellites can remain in space for decades and multiply exponentially as objects collide with one another on an ever-increasing basis. Eventually, scientists predict some orbits will become so congested that space will resemble an obstacle course.

"Imagine that all the car accidents that ever happened are still on the road and you have to drive around and not get hit by the wreckage," said Brian Weeden, technical adviser for Secure World Foundation, a Broomfield, Colo.-based nonprofit dedicated to space sustainability. "It's sort of like that."

'A WAKE-UP CALL'

The reality of space debris became starkly evident at least two times during the past decade. In 2007, China used a ground-based missile to destroy one of its weather satellites, creating about 3,000 pieces of debris in space.

Then in 2009, a defunct Russian military satellite collided with an active communications satellite owned by U.S. company Iridium Communications, generating another 2,000 pieces of debris.

"Those two events, back to back, were a wake-up call (to the international space community)," Weeden said.

And the more debris there is, the more difficult — and expensive — space missions become.

"By the end of the space shuttle program (in

This computer-generated image shows the location of objects orbiting within about 1,200 miles of the Earth's surface. At least 95 percent of the dots represent actual debris, not working satellites.

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Space debris could damage many key U.S. and European projects, including observation and communications satellites, as well as the International Space Station, seen at Earth's right.



P. CARRILL/ESA

2011), we were replacing, on average, up to two windows per mission because of small-debris impacts," said Eugene Stansbery, program manager of NASA's Orbital Debris Program Office, located at the Johnson Space Center in Houston. "So, there is real cost associated with damage from orbital debris."

Communication, convenience and security also are at risk. "As a society, we've become more and more dependent on space assets," said Col. John W. Giles, commander of the 614th Air and Space Operations Center and director of the Joint Space Operations Center (JSpOC) at Vandenberg Air Force Base in California. "If one of our satellites comes into contact with a piece of debris ... it could cause catastrophic damage."

A range of ground services, including weather forecasting, Global Positioning System (GPS) navigation, military communications and satellite television, just to name a few, could be interrupted by a collision.

"People always ask, 'What's it going to take for the public to start caring about debris?'" Baiocchi said. "We sometimes joke that it's going to take a satellite going out on Super Bowl Sunday."

This undated photo shows where a piece of debris went through the antenna dish on the Hubble Space Telescope.



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FENCES AND GARBAGE TRUCKS

The probability of a debris disaster is small, but growing, experts say. "A collision between an active satellite and a piece of debris larger than a marble usually spells doom for the satellite," said Laura Grego, a senior scientist in the Union of Concerned Scientists' Global Security Program, which studies space security. "Under current conditions you can expect that to happen

every two to three years."

To keep debris in check, the global space community is engaged in three solutions, the first of which is mitigation. The United Nations in 2008 adopted a set of voluntary international guidelines designed to reduce debris creation by promoting best practices in spacecraft engineering and disposal,

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STIJN LAAGLAND/ESA

A test on material that lessens the impact of flying debris on the space station resulted in shredded insulation, but a protective interior wall survived.

SPACE STATION ON ALERT

Satellites aren't the only space assets that must bob and weave to avoid collisions with space junk. The International Space Station (ISS) also is at risk. Whether debris is created by an accidental event, such as a collision, or a deliberate event, such as a missile strike, NASA has response protocols in place.

"When a piece of debris is in the area of the space station, we get a notification and work with the government agencies that track debris ... to understand where it's going and whether it's a threat," said Joel Montalbano, NASA deputy ISS program manager for utilization.

If it is a threat, "we have the ability to move the space station higher or lower to get out of harm's way, and we've done that 18 times since 1988," Montalbano said.

Although the ISS is engineered to withstand some impact, a major collision could cause the astronauts inside to take emergency measures. Astronauts undergo extensive preflight training simulating three emergency scenarios: depressurization, toxic spills and fires.

"If there is an event, the first thing ... to do is take readings of the atmosphere to see if there are any combustion products in the air," Montalbano explained. "Based on those readings, the crew has certain things to do."

If the astronauts' actions don't solve the problem, NASA is standing by 24/7 to bring them home. "We have two rescue vehicles on the space station," Montalbano said. "Worst-case scenario, the crew ... evacuates. We're prepared for them to do that at any time."

— Matt Alderton

Stansbery said.

The second solution is space traffic management. "On a daily basis, we do orbital forecasts that tell us whether ... objects are going to come in close proximity to each other, and whether they're at risk of colliding," Giles said.

JSpOC uses a global network of ground-based sensors to watch the sky, detecting space-borne objects and projecting their flight path as they pass overhead. The system identifies about 40 close approaches a day. When it discovers a potential conjunction, JSpOC alerts the satellite operator, who may be able to maneuver the satellite to avoid a collision.

In the U.S., the sensors used to monitor space are known collectively as "Space Fence." Although the original Space Fence ceased operations in 2013 — a casualty of the federal government's sequestration — the contract for a new Space Fence was awarded to Lockheed Martin in June. Scheduled for completion in 2019, it will allow JSpOC to track smaller objects at higher altitudes and with increased speed and accuracy.

"Most of the debris we can see right now is basketball-sized," Giles said. "The (new) Space Fence will allow us to see things down to the size of a golf ball."

Improved tracking may reduce collisions, but eliminating them requires a third solution: remediation. Ideas abound but none has been tested. Japan, for instance, wants to develop a giant magnetic net that will capture orbital debris. Other proposals include attaching tethers to pieces of debris, which will slow them down enough to pull them into Earth's atmosphere. Others suggest creating laser "brooms" that sweep debris into higher orbits, away from satellites, or building space-borne "garbage trucks" that collect debris and then dispose of it.

"At some point in the future, we will need to do debris removal," Stansbery said. "However, right now there isn't a solution for removing debris that is both technically and economically feasible."

There are more than 60 countries and dozens of companies with satellites in orbit, but no international body regulates them.



Radar stations in Tyngsboro, Mass., serve as NASA's main sentry for tiny bits of space debris, some as small as one centimeter. The radar collects 600 hours' worth of data per year.

REGULATING RUBBISH

There are more than 60 countries and dozens of companies with satellites in orbit, but no international body regulates them. In addition to engineering and economic challenges, space debris also faces significant political headwinds. Governments must collectively decide, for instance, who owns debris, who's responsible for creating it and who will pay to clean it up. As a result, policies must be crafted before the garbage trucks can take flight.

"Building garbage trucks is pretty straightforward. The hard part is convincing other countries it's OK for the U.S. to start shooting lasers into space," said Baiocchi, adding that most solutions for tracking and remediating debris also could be used as weapons or for espionage. "Starting the policy discussions today about which solutions are palatable ... is really important."

So, orbital bric-a-brac will continue accruing until someone finally makes a Space Swiffer. ●

'GRAVITY': FACT OR FICTION?

In the 2013 film *Gravity*, actors George Clooney and Sandra Bullock dodge debris from a destroyed satellite. While the phenomenon is fact, its dramatization is fiction.

"The basic (premise) is real, but the time scale is wrong; it happens over decades, not minutes," said Brian Weeden, technical adviser at Secure World Foundation. "Also ... space debris travels at speeds of about 17,000 miles per hour; there's no way you could see that coming or react in time."

— Matt Alderton



The movie *Gravity* shows a vastly sped-up version of what would happen if debris collided with the space station.